are taken in powder form and done using XRD-6100 (Shimadzu) diffractometer with Copper K_α radiation. The infrared spectra were recorded in the wave number range 400-2000 cm^{-1} using IR Affinity-1s (Shimadzu) spectrometer using KBr pellet technique at room temperature.

3. Results and Discussion

3.1 Physical Parameters

Using conventional formulae [13], density (ρ) of the synthesized glass samples, total molecular weight M of glass samples, various physical parameters such as transition metal ion concentration (Manganese ion), mean separation (r_i), polaron radius (r_p) and Optical basicity (Λ_{th}) values are determined.

3.11 Optical Basicity

The optical basicity of an oxide glasses can be conveniently measured in terms of the ability of the glass to donate a negative charge to an acidic probe ion [14-17]. Duffer and Ingram [18] reported that the optical basicity can be predicted from the composition of the glass and the basicity moderating parameters of various cations present. The theoretical values of optical basicity (Λ_{th}) of the SLCB glasses can be estimated using the formula,

$$(\Lambda_{th}) = \frac{\sum_{i=1}^{n} Zi\, ri}{2\gamma i} \quad (1)$$

where 'n' is the total number of cations present. Z_i is the 'is the oxidation number of the i^{th} cation to the number of oxides present and 'γ_i' is the basicity moderating parameter of the i^{th} cation. The basicity moderating parameter 'γ_i' can be calculated from the following equation

$$\gamma_i = 1.36(x_i - 0.26) \quad (2)$$

where x_i is the Pauling electro negativity of the cation [19]. The theoretical optical basicity values computed for the glasses in the present study are given in **Table 2**.

Table 2: Physical parameters of Manganese ions doped in SLCB glasses

Physical Parameters (Units)	Glass System			
	$SLCB_0$	$SLCB_1$	$SLCB_2$	$SLCB_3$
Average molecular weight(M)(g/mol)	67.69	64.01	67.70	71.39
Density (gr/cc)	2.65	2.79	2.67	2.54
Transition metal ion (N_i) Concentration (10^{+19}ions/cc) (±0.005)	…..	2.63	2.37	2.14
Inter ionic distance (r_i)(A^0)(±0.005)	…..	33.61	34.78	35.97
Polaron radius (r_p)(A^0)(±0.005)	…..	13.54	14.01	14.49
Optical basicity (Λ_{th})	0.43	0.43	0.43	0.43

It is observed that for the Λ_{th} values gradually increases from $SLCB_1$ to $SLCB_3$.

3.2 X-ray Diffraction Study (XRD)

The X-ray diffraction spectra have not shown any sharp peaks, indicating that the samples prepared are amorphous in nature are shown in **Figure 1**.

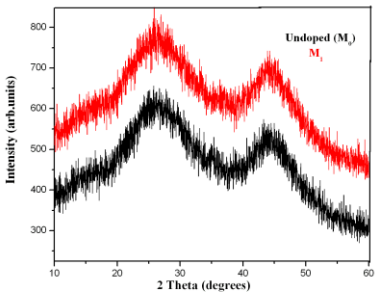

Figure 1: Powder X-ray diffraction patterns of undoped and Manganese ions doped SLCB glasses

3.6 FT-IR Studies

The FT-IR transmission spectrum is shown in Figure 2.

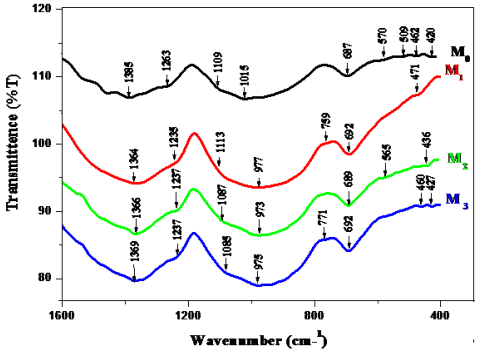

Figure 2: FT-IR spectra of Manganese ions doped SLCB glasses

The assignments of various absorption bands are given in **Table 3.**

The IR spectra have been divided into three spectral regions. The first group of band is reported to occur from 1200-

1600cm^{-1} which arise due to the asymmetric stretching vibrations triangular BO_3 units. The second group of bands region is from 800-1200cm^{-1} which was assigned to the stretching vibrations of tetrahedral BO_4 units. The third group observed around 700 cm^{-1} and was attributed to bending of B-O-B linkages in the networks. The band at 900 cm^{-1} was a characteristic of glass with high boric acid content i.e. due to boroxil rings [20].

Table 3: Assignments of absorption bands in the FTIR spectra of Manganese ions doped in SLCB glasses

M_0	M_1	M_2	M_3	Assignment
420	-	436	427	Ca-O stretching mode of BO_3 units.
462	471	-	460	Ca-O_6 stretching mode of BO_3 units.
509	-	-	-	Ca-O stretching mode of Borate units.
570	-	565	-	Ca-O stretching mode of Borate units.
687	692	689	692	B-O-B bending vibrations.
-	977	973	975	Boroxil ring vibrations.
1015	-	-	-	B-O-B stretching vibrations of BO_4 units.
1109	1113	1087	1085	Pyro-borate units, meta borate units.
1263	1235	1237	1237	Stretching vibrations B-O bonds in BO_3 units from pyro-ortho borate group's
1385	1364	1366	1369	Stretching vibrations of B (III)-O-B (IV) units.

The FT-IR spectrum of the undoped glass system contains three major broad bands with some shoulders in the wavenumber range of 400cm^{-1}- 460cm^{-1}, 500cm$^{-1,}$ 600cm^{-1}. These bands are the characteristics band vibrations of the calcium–oxygen. When Li_2O is incorporated in the glass, some of borons become tetrahedrally coordinated. The spectrum of fused B_2O_3 consists of a completely continuous triangle like coordinated network and also contains some BO_4 tetrahedral coordination. The band which lies in the region 800 cm^{-1} – 1200 cm^{-1} splits into two broad bands whose intensity increases with increase in mol% of SrO and decrease of mol% of Li_2O content. In the undoped glass with x=5 mol% SrO and 15 mol% Li_2O a shift in vibrational band at 1385 cm^{-1} is noticed with feeble increase in intensity. When x=10 mol% SrO and Li_2O, Li_2O causes a shift in the vibrational band from 1364 cm^{-1} to 1366 cm^{-1} with a noticeable increase in intensity of these peaks. Another band at 1235 cm^{-1} with x=10 mol% SrO and x=10 mol% Li_2O is assigned to stretching vibrations of B–O bonds in BO_3 units from pyro-ortho borate groups. The bands 1109cm^{-1},1113cm^{-1},1087cm^{-1} and 1085cm^{-1} are assigned B–O stretching vibrations of tetrahedral BO_4 units in tri-borate, tetra borate and penta borate groups [21]. The bands at 977cm^{-1},973cm^{-1}, and 975cm^{-1} are assigned to Boroxil ring vibrations. The bands 687cm^{-1},682cm^{-1},689cm-^{1} and 692cm^{-1} corresponds to B-O-B bending [22]. The bands 570cm^{-1},565cm^{-1},509cm^{-1} are due to stretching vibrations of CaO stretching mode of Borate units [23]. The absorption bands 462cm^{-1},471cm^{-1},460cm^{-1} and 420cm^{-1},436cm^{-1},427cm^{-1} corresponds to Ca-O_6 stretching mode of BO_3 units [24]. It is observed that on increasing of SrO content, the frequency bands shifts from higher to lower wavenumber, which suggests the formation of non bridging oxygen (NBO'S) i.e. conversion of BO_3 to BO_4 structural units. The formation of NBO'S indicates that the addition of Lithium oxide (Li_2O) in SLCB glasses act as a modifier.

4. Conclusion

From the physical and optical characterization of 0.1 mol% of Manganese ions doped xSrO + (20x) Li_2O + (10-y) CaO + 70B_2O_3 + y glasses with ($5 \leq x \leq 15$mol%) the following conclusions are drawn.

i. The density values are found to decrease with increase of SrO mol% or with decrease of Li_2O mol%. The density of undoped glass and the glass doped with Manganese oxide with 10 mol% of SrO and Li_2O are observed to be nearly equal.
ii. Powder XRD diffractograms confirm the glassy nature of the glasses under investigation.
iii. when x=5mol% of SrO and x=10 mol% Li_2O from the FT-IR spectra, the glass matrix is stable.

Acknowledgements

One of the authors **M. Ratna Raju**, F.No.APNA071, FDP/FIP-XI Plan, is thankful to the UGC-SERO, Hyderabad, for providing financial assistance under FDP Program to carry out this work.

References

[1] W.A. Weyl, Colored Glasses. Originally published in 1951 by the society of Glass Technology Sheffield. Reprinted by Dawson's of Pall Mall, London, 1959
[2] C.R. Bamford, Physics and Chemistry of Glasses, 3, 46, 1962
[3] A. Paul, Chemistry of Glasses, second ed., Elsevier, New York 1990
[4] M.A. Aglan, H. Moore, "Treatise on Materials Science and Technology," Journal of Society of Glass Technology, 39, pp. 351-84T, 1955
[5] J. Krogh-Moe, "Interpretation of the Infrared spectra of Boron oxide and alkali borate glasses," Physics and Chemistry of Glasses, 6 (2), pp. 46-54, 1965

[6] E.I. Kamitsos, A.P. Patsis, M.A. Karakassides, G.D. Chryssikos, "Infrared reflectance spectra of Lithium Borate glasses," Journal of Non Crystalline Solids, 126, pp. 52-67, 1990
[7] E.I. Kamitsos, A.P. Patsis, G.D. Chryssikos, "Infrared Reflectance investigation of alkali Diborate glasses," Journal of Non Crystalline Solids, 152, pp. 246-257, 1993
[8] E.I. Kamitsos, "Infrared studies of borate glasses," Physics and Chemistry of Glasses, 44 (2), pp. 79-87, 2003
[9] M.A. Zaki Ewiss, **"**Electrical, infrared spectroscopy and DTA studies of some sodium tetra borate glasses Containing Fe_2O_3," Physics and Chemistry of Glasses, 39 (4), pp. 236-240, 1988
[10] M.M. El-Desoky, "Dielectric behavior and AC Conductivity of sodium Borate Glass Containing CoO," Journal of Physics and Chemistry of Solids, 59 (9), pp. 1659-1666, 1998
[11] J.M. Jewell, "Model for the thermo-optic behavior of Sodium borate and sodium Alumino silicate glasses," Journal of Non Crystalline Solids, 146, pp. 145-153, 1992
[12] P.P.V. Reddy, C.L. Kanth, V.P. Kumar, N. Veeraiah, P. Kistaiah, "optical and thermo luminescence Properties of R_2O-RF-B_2O_3 glass systems doped with MnO," Journal of Non crystalline solids,351, pp.3752 -3759, 2005.
[13] A. Osaka, Yu-hu Wang, Masanori Kobayashi, Yoshinari, Katsuaki Takahashi, "Packing of atoms in lead halo silicate glasses of low silica content," Journal of Non Crystalline solids, 105, pp.63-68, 1988.
[14] A.J. Easteal, A.T. Morcom, "Variation of Optical basicity with probe ion for Cs_2O + B_2O_3 and Li_2O+B_2O_3 glasses," Journal of Non Crystalline Solids, 3(1), pp.29-35,1979
[15] M. Subhadra. Kistaiah, "Effect of BiO_2 content on Physical and optical properties of $15Li_2O$–$15K_2O$–xBi_2O_3–$(65-x)$ B_2O_3: $5V_2O_5$ glass system," Physica B: Condensed Matter, 406, pp.1501-1505, 2011
[16] A.J. Easteal, A.T. Marcom, "Variation of Optical basicity with probe ion for Cs_2O + B_2O_3 and Li_2O+B_2O_3 glasses," Journal of Non Crystalline Solids, 3(1), pp. 29-35, 1979
[17] L. Pauling, "The Nature of the Chemical Bond", Cornell University press, New York, 93, 1960
[18] J.A. Duffy, M.D. Ingram, "optical basicity-IV: Influence of electro negativity on the Lewis basicity and solvent properties of molten oxy anion salts and glasses," Journal of Inorganic Nuclear Chemistry,37, pp.1203-1206, 1975
[19] S. Anderson, R.L. Bohon, D.D. Kimpton, "Infrared Spectra and Atomic Arrangement in Fused Boron Oxide and Soda Borate Glasses," Journal of American Ceramic Society, 38, pp. 370-377, 1955
[20] E.A. Davis, N.F. Mott, "Conduction in non-crystalline systems V. Conductivity, optical absorption and Photoconductivity in amorphous semiconductors," Philosophical Magazine, 22, pp. 903-922, 1970
[21] E.I. Kamitsos, G.D. Chryssiko "Borate glass structure by Raman and infrared spectroscopies,"Journal of Molecular Structure, 247, pp.1–16, 1991
[22] S. Hazra, A. Gosh, "Structure and properties of Non conventional glasses in the binary bismuth cuprate System," Physics Review B, 51 (2), pp.851-856, 1995
[23] J. Lakshmi Kumari, J. Santhan Kumar, Sandhya Cole. "Spectral investigations on VO2+ ion doped in CaO–SrO–Na2O–B2O3 glass systems," Journal of Non Crystalline Solids, 357, pp.3734–3739, 2011
[24] P. Pascuta, "Structural investigations of some bismuth–borate–vanadate glasses doped with gadolinium ions," Journal of Materials Science-Materials in Electron, 21, pp.338–342, 2010

Author Profile

Dr. Sandhya Cole, M.Sc., M. Phil, Ph.D., She is working as Assistant professor in the department of Physics since 2006, Acharya Nagarjuna University, Nagarjuna Nagar, Guntur, A.P., India. Her research fields are Solid state Spectroscopy, Nanotechnology, Material Science, and Glass Materials. She is a life member of several scientific bodies like Indian Association of Physics Teachers, Indian Physics Association and associated fellow of A.P. Akademy of sciences, A.P, 2014. She has successfully completed UGC major research project. She also received best research paper award in sciences-2014. At present 15 research scholars including one CSIR-UGC (SRF) fellow and two BSR research fellows are working for their research degree under her guidance.

Mr. M. Ratna Raju is working as lecturer in Physics, Andhra Christian College, Guntur, A.P, India. He is having 19 years of teaching experience. He is currently associated with research for his Ph.D., work under UGC (FIP) program under the guidance of Dr. Sandhya Cole.

M. Subba Rao had received his M.Sc., degree in Physics with specialization in condensed Matter physics from Department of Physics, Acharya Nagarjuna University, Nagarjuna Nagar, Andhra Pradesh, India. He is currently Ph.D., Student in the field of Solid State Spectroscopy and Nanomaterials. He is CSIR-UGC (SRF) Fellow and he had attended International and national Conferences, workshops and International Symposium. Under the guidance of Dr. Sandhya Cole.